Materials Today: Proceedings xxx (xxxx) xxx

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Carbon catalyst from palm kernel shell (PKS) for methane cracking: Effect of preparation

Nurul Fathin Syuhada Hazman, Muhammad Syafiq Mat Zaki, Asmida Ideris *

Faculty of Chemical and Process Engineering Technology, Universiti Malaysia Pahang, Lebuh Persiaran Tun Khalil Yaakob, 26300 Kuantan, Pahang, Malaysia

ARTICLE INFO

Article history:
Available online xxxx

Keywords:
Palm kernel shell
Carbon catalyst
Pyrolysis
Methane cracking

ABSTRACT

The effect of preparation on the performance of carbon catalyst derived from palm kernel shell (PKS) in methane cracking was evaluated. The PKS-carbon catalysts were prepared via pyrolysis at different temperatures (550, 650, 750 °C) and for different pyrolysis times (30, 60, 100 min) and their catalytic performance in methane cracking was analysed in a fixed bed reactor. The BET surface area of the PKS-carbon catalyst increased from 40.7 to 43.0 m^2/g as the pyrolysis temperature increased from 550 to 650 °C, but decreased to 24.1 m^2/g at 750 °C. During methane cracking, the PKS-carbon catalyst prepared at 650 °C demonstrated 30 % initial CH_4 conversion and gave the highest initial H_2 yield of up to 88 %. This indicates that pyrolysis temperature influences the carbon catalyst's surface area, and a higher surface area promotes better initial catalytic activity in methane cracking. In addition, the PKS-carbon catalyst prepared for longer pyrolysis time (100 min) contained more desirable surface oxygen-containing functional groups (–OH, C=O, –COOH) than the ones prepared for 30 and 60 min. Therefore, the PKS-carbon catalyst pyrolyzed for 100 min exhibited 35 % initial CH_4 conversion and the highest initial H_2 yield of 95 %. This suggests that a longer pyrolysis time produces more desirable surface oxygen-containing functional groups, which enhance reactant activation in methane cracking. In conclusion, the preparation of PKS-carbon catalyst influences the surface area and surface oxygen- containing functional groups, which affect the catalyst's performance in methane cracking.

Selection and peer-review under responsibility of the scientific committee of the 6th International Conference of Chemical Engineering & Industrial Biotechnology (ICCEIB 2022).

1. Introduction

Methane cracking is an environmentally friendly method for producing H_2 since it emits no CO_x. The process decomposes into H_2 and solid carbon, but the stable C-H bonds in CH_4 molecules require high temperatures. Therefore, catalysts are necessary to lower the activation energy [1]. Metal-based catalysts, such as Ni-based and Fe-based, are commonly used for methane cracking due to their catalytic activity [2,3]. However, the main challenge with metal-based catalysts is catalyst deactivation caused by carbon deposition on the catalyst surface, which covers the active metal sites [4]. As carbon generated from methane cracking itself is also active as a catalyst [5], researchers have explored using carbon catalysts for methane cracking. Carbon catalysts offer several advantages, such as low cost, high resistance to carbon deposition, and high thermal stability [6,7].

The use of carbon catalyst for methane cracking has attracted significant interest from researchers. Patel et al. has synthesized a carbon catalyst from the biosolids of aerobic and anerobic digesters and utilized it for methane cracking, achieving initial methane conversions of 16 and 52 % at temperatures of 700 and 900 °C, respectively [8]. Liu et al. employed coconut shells to produce carbon-based catalyst for methane cracking, achieving initial methane conversions of 50, 70 and 87 % at temperatures of 900, 950 and 1000 °C, respectively [9]. In a recent study, Zhao et al. used a green alga, *Enteromorpha prolifera*, as a precursor to synthesize carbon catalyst. When activated with H_3PO_4, this catalyst achieved with a maximum initial methane conversion of 45 % during methane cracking at a temperature of 850 °C [10]. Although carbon catalysts offer several advantages over metal-based catalysts, they exhibit lower catalytic activity [11,12]. Therefore, improving the properties of carbon catalyst is crucial to ensure their feasibility for methane cracking.

The preparation of carbon catalyst from biomass typically involves pyrolysis, where the resulting properties for catalytic reaction are

* Corresponding author.
E-mail address: asmida@ump.edu.my (A. Ideris).

https://doi.org/10.1016/j.matpr.2023.03.566
2214-7853/
Selection and peer-review under responsibility of the scientific committee of the 6th International Conference of Chemical Engineering & Industrial Biotechnology (ICCEIB 2022).